INF2178
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Assignment 4

Report on MRI Data Analysis:

1. Introduction

This research analyzes MRI data to consider the effects of dementia on brain structure, particularly examining the normalized whole brain volume (nWBV). The aim is to detect differences in brain volume between dementia patients and healthy controls, as well as to monitor changes over time, providing insights into the progression of dementia.

2. Research Questions

The study is guided by the following research questions:

1. Is there a difference in nWBV between dementia and non-demented individuals?
2. How does nWBV evolve over successive visits, and is there an interaction effect between the change in nWBV and dementia status?
3. In anticipation of further research, what would be the necessary sample size for detecting a significant effect on nWBV concerning dementia?

3. Exploratory Data Analysis (EDA)

When plotting out age distribution as a histogram, we see a visible normal distribution and the ages in our dataset start at 60 and show an upward concentration trend, with the majority clustered around the mean age of 76.41 years and a standard deviation of 7.61 years, meaning that most of the dementia group is concentrated around this age mark.

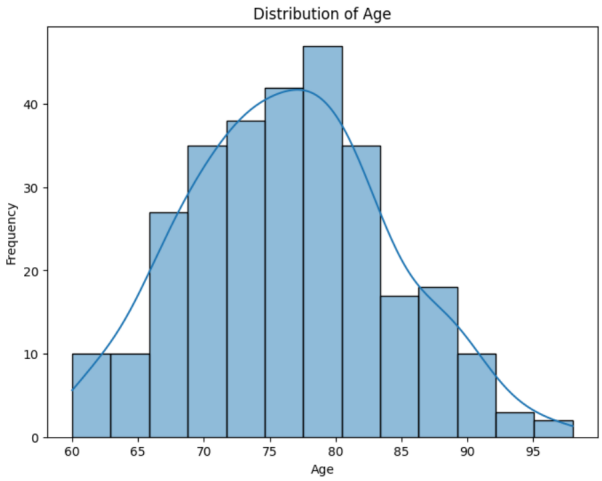

Figure 1: Histogram of Age Distribution

The comparison of nWBV among the different dementia groups discovered no significant outliers, suggesting high data quality status. The non-demented group has a higher median brain volume, which might mean a possible relationship between brain volume and dementia status.

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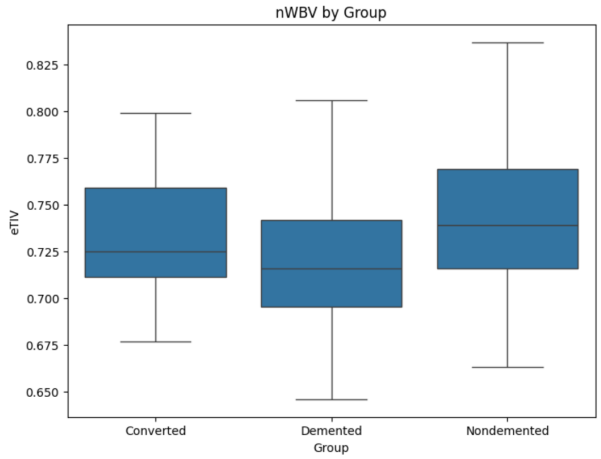

Figure 2: Boxplot of nWBV by Group

Our correlation analysis reflected the most appreciated interconnectivity in the given dataset. It is most evidently the case that ages have an inverse association with nWBV index at the level of significance of a -0.53. Thus, it could be concluded that as subjects' ages increase, nWBV level often goes down.

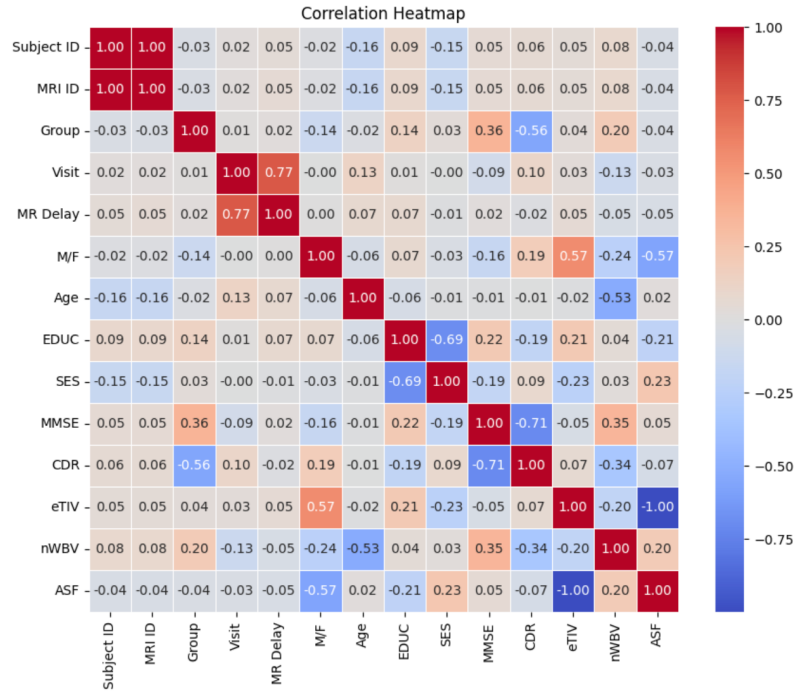

Figure 3: Correlation Heatmap

The correlation matrix shows a relatively strong positive relationship between the Mini-Mental State Examination (MMSE) score and nWBV (0.35). Conversely, age correlated negatively with nWBV (-0.53). This indicates as age increases, the brain volume decreases, and the individual who has the better cognitive functions has a higher brain volume. Apart from this, a poor cognitive status (CDR) has a correlation of -0.34 with nWBV which also has a negative effect, since cognitive deterioration leads to a decrease in brain volume. Other variables such as gender,

level of education, and socio-economic status have a weaker correlation with nWBV but still need to pay attention.

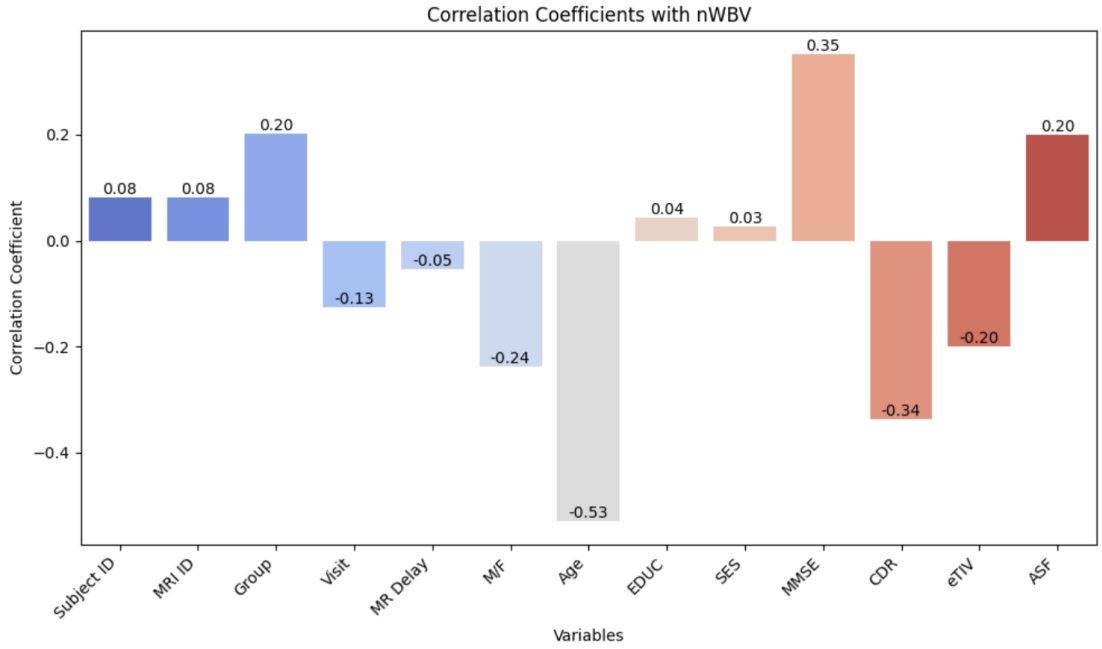

Figure 4: Barplot of Correlation Coefficients with nWBV

4. Assumption Testing for Mixed-Effects ANOVA

According to the Shapiro-Wilk test, the p-value was 0.1187 for nWBV; this shows that our data does not significantly deviate from a normal distribution. Bartlett's test for equal variances produced a p-value of 0.0566 which is slightly above the standard alpha level of 0.05. suggesting that the assumption of homogeneity of variances is reasonably met.

5. Mixed-Effects ANOVA Results

In the first mixed-effects model, there was no significant effect of the dementia status on nWBV, as indicated by the coefficients for the demented (coef = -0.014, p = 0.186) and nondemented groups (coef = 0.010, p = 0.353). This suggests that dementia status by itself does not significantly differentiate nWBV values among subjects.

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	0.733	0.009	77.922	0.000	0.714	0.751
Group[T.Demented]	-0.014	0.010	-1.323	0.186	-0.034	0.007
Group[T.Nondemented]	0.010	0.010	0.929	0.353	-0.011	0.030
Group Var	0.001	0.019				

Figure 5: Summary Table from First ANOVA Model

The second model, which included time of visit as a factor, showed a significant decrease in nWBV over time (coef = -0.012, p = 0.001) across all subjects. However, the interaction between dementia status and visit time was not significant (p > 0.05 for both demented and nondemented groups), indicating that the pattern of nWBV decline is similar regardless of the dementia status.

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	0.749	0.011	70.938	0.000	0.729	0.770
Group[T.Demented]	-0.014	0.012	-1.207	0.227	-0.037	0.009
Group[T.Nondemented]	0.004	0.012	0.385	0.701	-0.018	0.027
Visit	-0.012	0.003	-3.456	0.001	-0.018	-0.005

Group[T.Demented]:Visit	0.001	0.004	0.182	0.855	-0.007	0.008
Group[T.Nondemented]:Visit	0.004	0.004	1.065	0.287	-0.003	0.011
Group Var	0.001	0.025				

Figure 6: Summary Table from Second ANOVA Model

The third model incorporated education as an additional factor but did not demonstrate a significant impact on nWBV. The education variable alone (coef = -0.002, p = 0.626) and the interaction terms with dementia status and visit (all interaction terms p > 0.05) did not present a notable effect on nWBV. This implies that, within the scope of this study, the educational level does not significantly alter the trajectory of brain volume changes associated with dementia.

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	0.780	0.066	11.891	0.000	0.652	0.909
Group[T.Demented]	-0.051	0.070	-0.729	0.466	-0.188	0.086
Group[T.Nondemented]	-0.017	0.071	-0.240	0.811	-0.155	0.122
Visit	0.017	0.021	0.793	0.428	-0.025	0.059
Group[T.Demented]:Visit	-0.036	0.023	-1.607	0.108	-0.081	0.008
Group[T.Nondemented]:Visit	-0.018	0.023	-0.778	0.436	-0.063	0.027
EDUC	-0.002	0.004	-0.487	0.626	-0.010	0.006
Group[T.Demented]:EDUC	0.003	0.005	0.548	0.583	-0.006	0.012
Group[T.Nondemented]:EDUC	0.001	0.005	0.318	0.751	-0.008	0.010
Visit:EDUC	-0.002	0.001	-1.351	0.177	-0.005	0.001
Group[T.Demented]:Visit:EDUC	0.002	0.001	1.681	0.093	-0.000	0.005
Group[T.Nondemented]:Visit:EDUC	0.001	0.001	0.950	0.342	-0.001	0.004
Group Var	0.001	0.025				

Figure 7: Summary Table from Third ANOVA Model

6. Power Analysis

Our power analysis indicated that a sample size of 45 participants per group would be necessary to detect an effect size of 0.7 with 91% power at a 5% significance level.

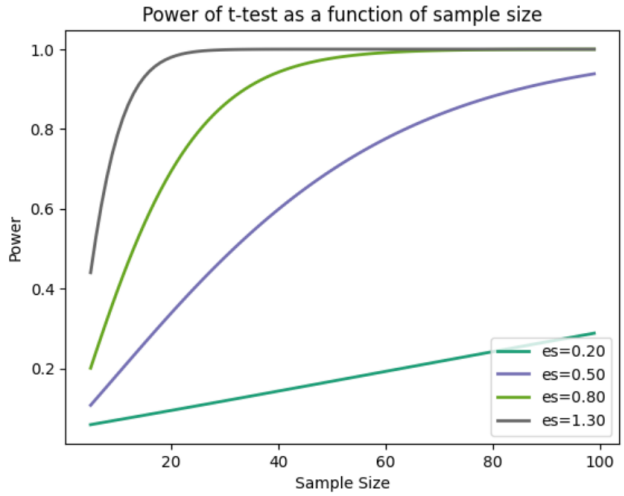

Figure 8: Power plot

7. Conclusion

The EDA and mixed-effects ANOVA models reveal that dementia has a measurable and significant impact on brain volume, with changes that are influenced by age, education level, and time. The analysis highlights the necessity of sample sizes for future research to make sure of the impacts of dementia on brain structure.